

CHANGES IN SATURN'S SOUTH-TEMPERATE HAZE DISTRIBUTION
DURING THE SUMMER OF 1973-1980

L. Trafton
University of Texas at Austin

The presentation by Trafton is largely contained in a paper appearing in *Icarus* (1985; 63, 374-405). The abstract of that paper is reproduced here:

We report the results of monitoring Saturn's H_2 quadrupole and CH_4 band absorptions outside of the equatorial zone over one-half of Saturn's year. This interval covers most of the perihelion half of Saturn's elliptical orbit, which happens to be approximately bounded by the equinoxes. Marked long-term changes occur in the CH_4 absorption accompanied by weakly opposite changes in the H_2 absorption. Around the 1980 equinox, the H_2 and CH_4 absorptions in the northern hemisphere appear to be discontinuous with those in the southern hemisphere. This discontinuity and the temporal variation of the absorptions are evidence for seasonal changes. The absorption variations can be attributed to a variable haze in Saturn's troposphere, responding to changes in temperature and insolation through the processes of sublimation and freezing. Condensed or frozen CH_4 is very unlikely to contribute any haze. The temporal variation of the absorption in the strong CH_4 bands at south temperate latitudes is consistent with a theoretically expected phase lag of 60° between the tropopause temperature and the seasonally variable insolation. We model the vertical haze distribution of Saturn's south temperate latitudes during 1971-1977 in terms of a distribution having a particle scale height equal to a fraction of the atmospheric scale height. The results are a CH_4/H_2 mixing ratio of $(4.2 \pm 0.4) \times 10^{-3}$, a haze particle albedo of $\omega = 0.995 \pm 0.003$, and a range of variation in the particle to gas scale-height ratio of 0.6 ± 0.2 . The haze was lowest near the time of maximum temperature. We also report spatial measurements of the absorption in the 6450 \AA NH_3 band made annually since the 1980 equinox. A $20 \pm 4\%$ increase in the NH_3 absorption at south temperate latitudes has occurred since 1973-1976 and the NH_3 absorption at high northern latitudes has increased during spring. Increasing insolation, and the resulting net sublimation of NH_3 crystals, is probably the cause. Significant long-term changes apparently extend to the deepest visible parts of Saturn's atmosphere. An apparently anomalous ortho-para H_2 ratio in 1978 suggests that the southern temperate latitudes experienced an unusual upwelling during that time. This may have signaled a rise in the radiative-convective boundary from deep levels following maximum tropospheric temperature and the associated maximum radiative stability. This would be further evidence that the deep, visible atmosphere is governed by processes such as dynamics and the thermodynamics of phase changes, which have response times much shorter than the radiative time constant.

DR. WEST: I had a lot of trouble understanding your ratios for the S(0) and S(1) lines because you used Bragg's line strengths which differed by a factor of more than four at room temperature and a factor of something like two at colder temperatures for both equilibrium and normal hydrogen. There is no way you can get a ratio anywhere close to one. The S(0) strength should always be weaker than the S(1) strength. What did you use for those...

DR. TRAFTON: I did not use Bragg's experimental line strengths; I used the theoretical ones instead. These imply a ratio which is close to that of hydrogen's at equilibrium for the Voyager temperature distribution (except for 1978). The difference between the laboratory and theoretical values presumably explains the different ratios.

DR. TOMASKO: I wasn't sure I understood how you went about reconciling the 6200 Å weak methane feature. It sounded like you extracted a single scattering albedo to make that data consistent. Is that right? If you used a lower single scattering albedo like 0.98, it wasn't so consistent, but if you used 1 then it was more nearly consistent.

DR. TRAFTON: Exactly. I did it for two extreme cases, and the higher albedo gave the better fit.

DR. TOMASKO: I think the independent absolute photometry of Saturn indicates that the albedo is somewhat closer to the lower value than the higher value. We've done some analysis of methane features on Saturn. When we used the published observed numbers for the single scattering albedo, we have again the same trouble of making the weak features fit when the strong ones do, but we don't see an easy way out of that.

DR. TRAFTON: The validity of what I've done is dependent upon the validity of the haze model. The model assumes a strict scale-height distribution in the scatterers. If that is not true, if there is a top to the haze, then I expect the results to be closer to those that you find for the equatorial region of Saturn and closer to those which you describe. The extent to which this model is valid is the degree to which you get the same derived methane to hydrogen ratio for each independent analysis of each methane band.

DR. BAINES: I hold the opinion that the 6190 Å band is not the band that we should be using to screen atmospheric properties. I think there are problems due to temperatures. I'm having a hard time making that band work for Uranus--I haven't got anywhere on that. There are definitely some weak links. I think Bill Smith will say something about recent measurements in the laboratory system. He definitely sees asymmetries between the shapes, and it's not a single band. That may be a problem in too many of our analyses, that we rely too much on that band, when we should put low weight on it.

DR. TRAFTON: Well, that is just one band out of five in this analysis. The 8600 Å angstrom band also supports this same conclusion.

DR. POLLACK: I wish to pursue the matter of temperature dependence. The absorption spectrum that everybody uses is measured at room temperature in the laboratory. Question: is that valid at the temperatures of the outer planets?

My answer to that is to compare that with absorption coefficients that you get from liquid methane, which gives you a first approximation to that answer. It turns out that at the center of many of the bands, the absorption coefficients are very similar. So that at the center of bands, I think this approximation is safe. On the other hand, as you get towards the wings, you definitely get different results between room temperature coefficients and those of liquid methane, so you are really on thin ice there. I think what that means is that equivalent widths put you on somewhat shaky ground, and if you use the full line shape you are on very shaky grounds. The best thing to do is to be in the center of the band.

DR. TRAFTON: Yes, I agree.

DR. LUNINE: I just want to reply to Jim Pollack: that is that there is a difference in line shapes between liquid methane and methane vapor. Admittedly, liquid methane gives you a first approximation, but it might be dangerous to try to use the liquid methane to specify the absorption coefficients for the vapor, particularly in the far wings of bands. There is a redistribution of line strengths in those bands, for liquid versus gaseous methane. There are some published studies that I can show you.